Environmental regimes in the Caribbean and implications for the dynamics and distribution of its coral reefs

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: ………………………………………………………………………..

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I.

Abstract

Over evolutionary time coral reefs have been exposed to the influence of diverse environmental forces which have determined their structure and function. However, the climate of the earth is changing, affecting many biological systems, including coral reefs. Through this thesis the static and dynamic environment of the Caribbean basin was characterized using remote sensing and *in situ* data sources. This information was used to understand how present environmental conditions have shaped reef ecosystems and how the changing climate might jeopardize them.

Focusing on physical constraints that drive many aspects of coastal ecology, a region-wide categorisation of the Physical Environments of the Caribbean Sea (PECS) was developed. The classification approach is hierarchical; including a first level of 16 physicochemical provinces based on sea surface temperature, turbidity and salinity data; and a second level considering mechanical disturbance from wave exposure and hurricanes. The PECS categorisation will facilitate comparative analyses and inform the stratification of studies across environmental provinces in the region.

Montastraea spp. forereef habitats have the highest biodiversity and support the largest number of ecosystem processes and services in the Caribbean. One of the aspects of the physical environment, wave exposure, was used to predict the distribution of these habitats in the Caribbean basin with high accuracy (79%). The distribution of the habitat is constrained in environments of high exposure, a pattern likely to be driven by high rates of chronic sediment scour that constrain recruitment. This approach constitutes a fast and inexpensive alternative to traditional habitat mapping and complements global efforts to map reef extent.

Recent changes in temperature have impacted ecosystem function across the globe. However, the nature of the responses has depended upon the rate of change of temperature and the season when the changes occur, which are spatially variable. In the Caribbean Sea, temperature trends are highly variable in space (ranging from -0.20 to 0.54°C decade^{-1}) and most of the warming

has been due to increases in summer temperatures. The highly detailed spatial and temporal patterns assessed can be used to elucidate observed ecological responses to climatic change in the region.

In the face of increased temperatures it has been suggested that reefs may become increasingly restricted to locations of naturally low thermal stress, such as upwelling areas. However, when analysing the degree to which seasonal upwelling reduces the local thermal stress experienced by corals, it is clear that upwelling areas do not always offer meaningful protection. Hypothesised areas need to be assessed individually in order to evaluate their capacity as a refuge against climate change.

In this thesis large progress has been made in assessing the ocean climate of the Caribbean basin by quantifying spatial patterns and their rate of change. Although some insight into the consequences of these seascape patterns to the function and distribution of marine systems has been provided, more can be done to fully exploit the datasets produced.

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